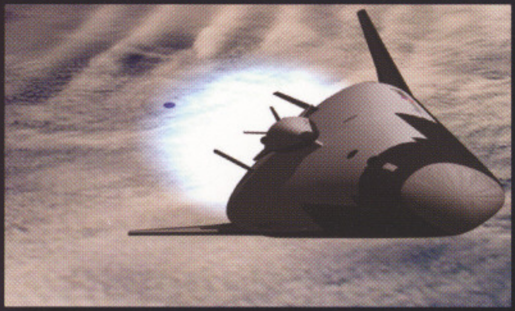
Control Science

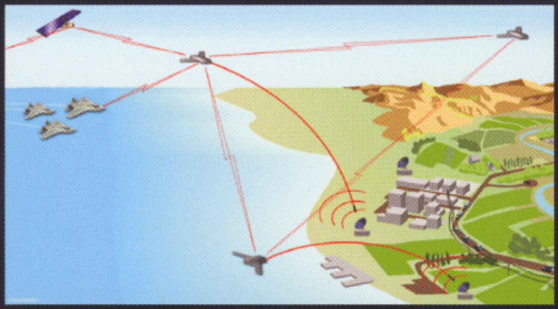
Center of Excellence

The Cutting Edge in Control Science Research...

The Next 100 Years Start Right Here

Introduction to the Control Science *Center of Excellence*

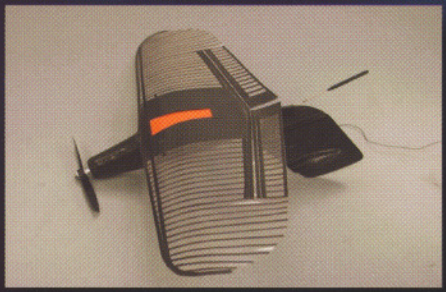


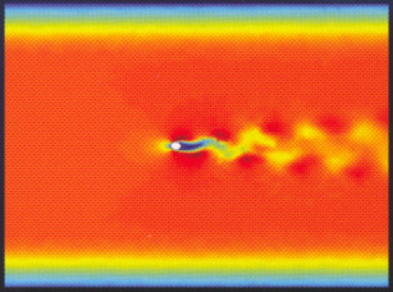


Wright-Patterson Air Force Base has been the center of aerospace technology development since the Wright Brothers first developed airplanes at their nearby Dayton, Ohio bicycle shop and test flew their designs at Huffman Prairie, now a part of the base. The Air Force Research Laboratory, headquartered at Wright-Patterson AFB, maintains this tradition as one of the largest complexes in the world dedicated to excellence in the aerospace sciences. The Control Science Center of Excellence, a part of AFRL's Air Vehicles Directorate, is the Laboratory's leader in the development of the control technologies necessary to maintain the United States Air Force as the preeminent aerospace power.

The Control Science Center of Excellence is staffed by a highly professional cadre of award-winning civil service scientists and Air Force officers who form the technical core of the Center's competencies. This core is augmented by numerous visiting scientists who provide a fresh perspective to the Center's tasks. This partnership ensures that the Center maintains its technical preeminence.

The Center's research tasks cover a wide spectrum of aerospace science applications. From air vehicles to trans-atmospheric vehicles, including both manned and unmanned aerial vehicles, the Control Science Center of Excellence is tasked with developing and transitioning advanced control technologies for all aspects of the 21st century air and space force.

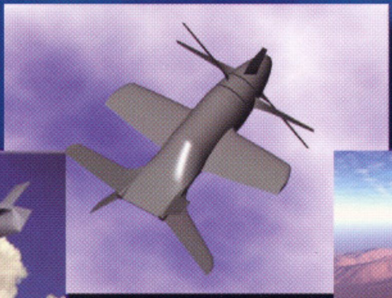


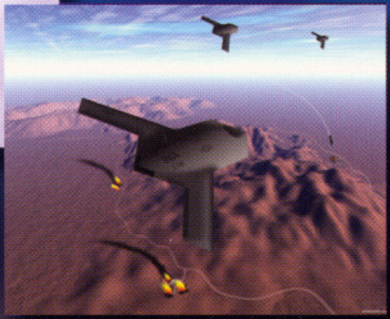


Unmanned Aerial Vehicle Control

In the future, unmanned aerial vehicles (UAVs) will operate in teams to autonomously perform complex, cooperative tasks such as destruction of enemy threats and time-critical targets. As such, these vehicles will require distributed algorithms for making decisions that meet team goals and mission objectives. Cooperative control of UAVs is a complex problem that is dominated by task coupling, limited information, and a high degree of uncertainty. We are developing algorithms for real-time multiple-task assignment with complex task constraints. Additionally, we are developing decentralized decision and control algorithms to provide robustness and flexibility.

As these teams of UAVs will operate in uncertain and adversarial environments, communications will be critical. The effects of network communication delays on team assignment decisions are being investigated. Delays can create instability, limit cycles, and a loss of cohesion as a team. We are developing metrics and control strategies that enable us to maintain or gracefully degrade coordinated team performance despite arbitrary communications delays and highly dynamic events. In addition, information theory and game theory are being pursued to address uncertainty about the environment and the adversary in battle-space operations with heterogeneous vehicles. An exciting new field of investigation is the cooperative control of a team of small and micro air vehicles in urban environment missions. This scenario presents significant challenges with the combination of high uncertainty, with limited sensors, processing, and communication.

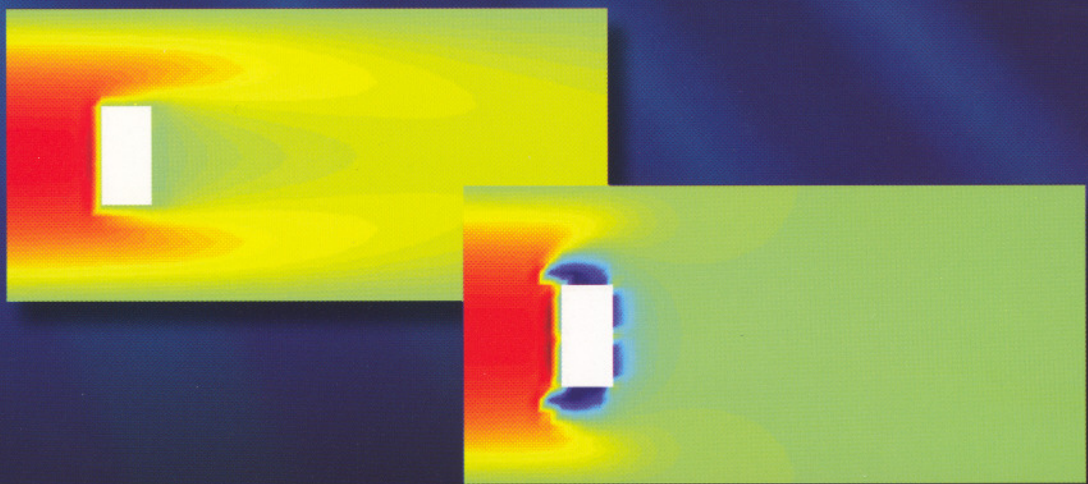




Feedback Flow Control

The integration of feedback control with active flow control, for example, synthetic jets or pulsed jets, will enable the development of aircraft with designs optimized for requirements other than aerodynamic performance. Research in this multidisciplinary effort is focused on developing methods for modeling the input/output relationships between flow control actuators and the aerodynamic response and on control law design. The Center of Excellence's flow control effort is advancing the state of the art in building reduced-order flow control models from simulation data, with emphasis on models that are amenable to control law design.

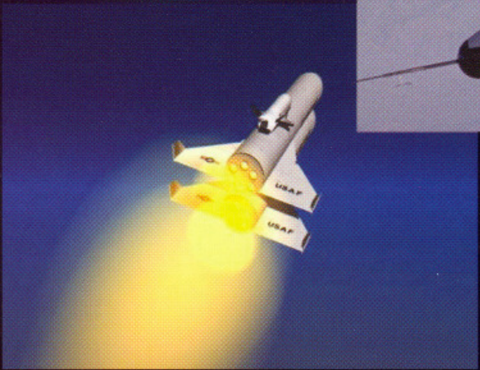
Applications of this technology include drag reduction, noise reduction, and ultimately the ability to use flow control devices in place of traditional aircraft control surfaces through separation control or virtual aerodynamic shaping. A near-term objective is improved fuel efficiency of air and ground vehicles through reduced drag. Improved fuel efficiency will result in increased range, loiter time, and payload. Another application is reduction of structural loads in weapons bays by lowering acoustic levels, as well as noise reduction in automobile passenger compartments. Maneuvering aircraft without deflecting control surfaces, such as ailerons and elevators, will help air vehicles survive in hostile environments.

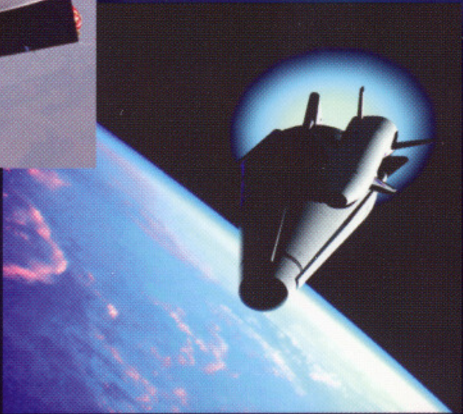


Space Access Guidance & Control

We are developing guidance and control technologies that will enable the Air Force to realize the goals of low-cost, responsive, and reliable access to space. Space access vehicles of the future will largely be autonomous and will require new guidance, control, and trajectory generation technologies. Current efforts are focused on leveraging over two decades of research and development in the area of adaptive and reconfigurable control systems for piloted aircraft. Autonomous vehicles require adaptive guidance and trajectory reshaping algorithms to fulfill the adaptive role that a human pilot plays in manually controlled vehicles. Reconfigurable control technology extends beyond aerospace platforms into a variety of applications in the military and industrial sectors.

The long-term vision for space access vehicles includes the development of hypersonic air-breathing vehicles. Supersonic combustion ramjet (SCRamjet) engines on the horizon use oxygen from the atmosphere to provide the oxidizer required for combustion before transitioning to rocket-based propulsion in space. Many challenges must be overcome in order to develop a SCRamjet-powered vehicle. We are focusing on challenges associated with the control of an integrated airframe-propulsion system that typifies these vehicle designs. Analytical modeling of these systems is being considered for the purpose of control law development.





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Expertise of the Center

The Control Science Center of Excellence is focused on cutting-edge control science issues of importance to the U.S. Air Force and the aerospace industry. The Center's technical excellence has been recognized through AFOSR Star Team designation and the Air Force Chief of Staff Award. Additionally, many of the Center's members have been individually recognized for technical excellence through the National Academy of Engineering, AIAA, and IEEE fellowship designation, technical committee and advisory board membership, and numerous awards from throughout the defense and aerospace community.

Our Commitment

We are committed to aggressive development of advanced control technology and its transition to both industry and the warfighter to improve total weapon system lethality, survivability, agility, performance, and affordability. Our ability to develop and apply control technologies to a wide spectrum of aerospace applications is critical to ensuring that the United States Air Force remains the world's preeminent aerospace power.

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